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Interactive Multimedia Module with Pedagogical Agents: Formative Evaluation

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Abstract

Electrochemistry is found to be a difficult topic to learn due to its abstract concepts that involve three representation levels. Research showed that animation and simulation using Information and Communication Technology can help students to visualize and thus enhance students' understanding in learning abstract chemistry topics. As a result, an interactive multimedia module with a pedagogical agent (IMMPA) named EC Lab was developed to assist students in the learning of Electrochemistry. There were 35 students and seven experts involved in this formative evaluation to test the usability and effectiveness of the module developed. Instruments involved were module evaluation questionnaire, module reliability questionnaire, module validity questionnaire, pretest, post-test and motivation questionnaire. Results showed that the students and experts rated the module developed as high (M = 3.94) and very high quality (M = 4.45). Besides, the respondents also see the module as reliable (M = 3.87) and valid (M = 4.51). Students have higher scores on their post-test and have gained higher motivation level after learning with the IMMPA EC Lab. However, some corrections and modifications have been made based on feedback and suggestions from the respondents to improve the quality of IMMPA EC Lab.

Keywords: interactive multimedia module, pedagogical agent, electrochemistry, formative evaluation

1. Introduction

1.1 Learning of Electrochemistry in Malaysia

Electrochemistry is the sixth chapter in the Malaysian Chemistry syllabus for secondary schools. This topic is taught to upper secondary level students in the science stream. Electrochemistry is a study of inter-conversion of chemical energy and electrical energy that occurs in electrolytic and voltaic cells. Previous studies (Bojczuk, 1982; Lee & Kamisah, 2010; Lin, Yang, Chiu & Chou, 2002; Roziah, 2005) showed that the topic is difficult to learn because the concepts are abstract. Students often encounter misconceptions in the learning of this topic (Garnett & Hackling 1993; Garnett & Treagust 1992; Garnett, Garnett & Hackling, 1995; Karsli & Çalik, 2012; Lee & Mohammad Yusof 2009; Lee 2008; Lin et al. 2002; Sanger & Greenbowe 1997a; Sanger & Greenbowe 1997b).

Macroscopically, students need to study the concepts of electrolytes and non-electrolytes, the electrolysis process and voltaic cells. Microscopically, they need to understand the movement of ions and electrons during the electrolysis process. Besides that, they need to transform the process into chemical formulae and equations symbolically. Students face difficulties in understanding the abstract chemical processes especially at the microscopic and symbolic levels (Garnett & Hackling 1993; Garnett & Treagust 1992; Garnett et al., 1995; Karsli & Çalik, 2012; Lee & Mohammad Yusof 2009; Lee 2008; Lin et al. 2002; Sanger & Greenbowe 1997a; Sanger & Greenbowe 1997b).

Studies (Doymus, Karacop & Simsek, 2010; Gois & Giordan, 2009; Lerman & Morton, 2009) showed that animation and simulation using information and communication technology (ICT) can help students to visualize and thus enhance students' understanding in learning abstract chemistry topics. The use of multimedia creates the environment where students can visualize the abstract chemical processes via animation and video at macroscopic, microscopic and symbolic levels (Bowen, 1998; Burke, Greenbowe & Windschitl, 1998;

Rodrigues, Smith & Ainley, 2001; Russell, Kozma, Jones, Wykoff, Marx & Davis, 1997).

Although the use of multimedia modules is able to assist students in visualizing the abstract concepts, students lack sufficient metacognitive awareness and comprehension monitoring skill to make effective choices (Hill & Hannafin, 2001; Land, 2000) in computer-mediated learning environments. They lack the skills to find, process and use information and ideas. Students as novice learners do not always make connections with prior knowledge or everyday experiences in ways that are productive for learning (Land, 2000). As a result, Pedagogical Agents (PAs) are designed to facilitate learning in computer-mediated learning environments (Chou, Chan & Lin, 2003; Craig, Gholson & Driscoll, 2002; Johnson, Rickel, & Lester, 2000; Moundridou & Virvou, 2002; Predinger, Saeyor & Ishizuka, n.d., Slater, 2000).

PAs in the interactive multimedia module serve to enhance students' metacognitive awareness of what they know and what they should know regarding the topic being studied. One of the strategies to provide metacognitive guidance involves embedding support, or scaffolds for procedural, strategic, or metacognitive control (Land, 2000). Such guidance and support are provided by the PAs in the module. PAs could make learners more aware of the opportunities presented to them, provide advice to learners on the tools to be used, and explain the functionalities of the tools in an open learning environment (Clarebout & Elen, 2007). Hence, an Interactive Multimedia Module with Pedagogical Agents (IMMPA) named EC Lab was developed to assist students in the learning of Electrochemistry.

1.2 Development of the IMMPA EC Lab

In this study, we developed IMMPA EC Lab in the learning of Electrochemistry by combining two instructional design models: Kemp Model (1994) and Gerlach and Ely Model (1980). The two models are combined as they are both classroom-oriented (Gustafson & Branch, 1997) with their own strengths. The model produced through the combination is named KemGerly Model and the conceptual framework of KemGerly Model is illustrated in Figure 1.

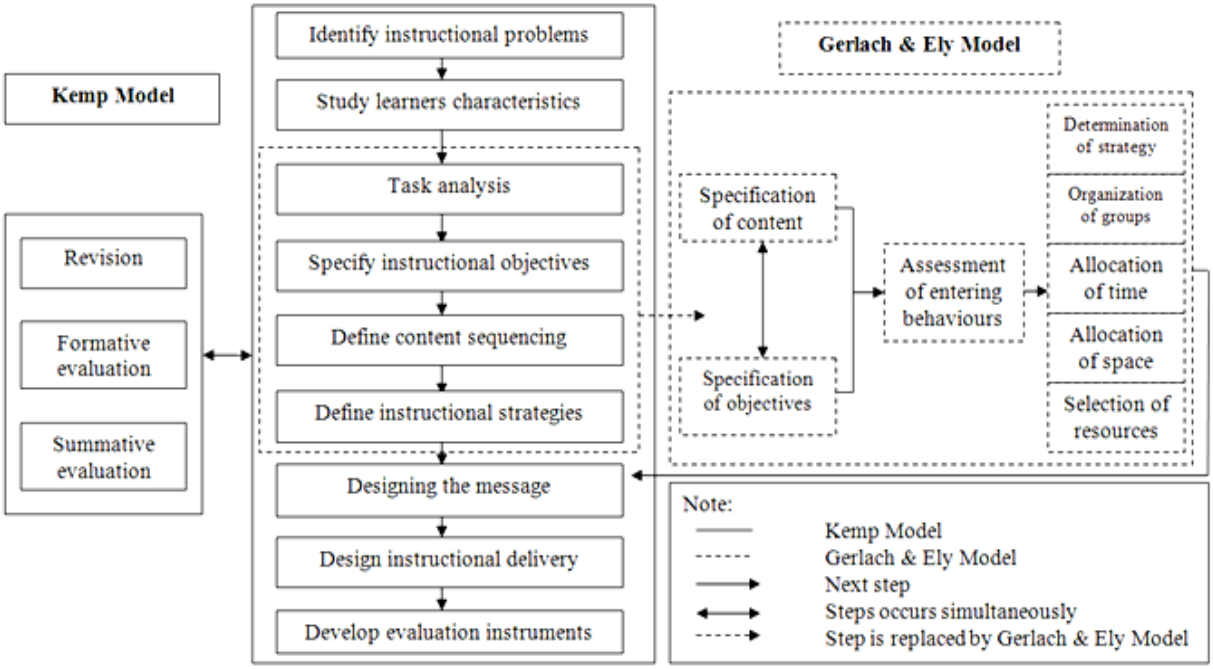

Figure 1. Conceptual framework of KemGerly Model

The Kemp Model describes elements, not steps, stages, levels or sequential items in an instructional design (Kemp, Morrison & Ross, 2004). The oval shape of the model indicates the independence of the elements in the model. It is a non-linear model with no starting and ending point. All the processes of designing, developing, implementing and evaluating can be done concurrently and continuously. The Gerlach and Ely Model is suitable for novice instructional designers who have knowledge and expertise in a specific context (Qureshi, 2001, 2003, 2004). This model is classroom-oriented and is suitable for teachers at secondary schools and higher education institutions. The Gerlach and

Ely Model focuses more on instructional materials and resources without identifying instructional problems. Hence, we have combined the two models as the instructional design model to develop the IMMPA EC Lab.

To develop IMMPA EC Lab, first of all, we need to identify instructional problems in Electrochemistry (Lee & Kamisah, 2010) and study learners' characteristics (Lee & Kamisah, 2012). Then, the four elements in the Kemp Model were replaced by some steps in Gerlach & Ely Model. We analyzed the contents of Electrochemistry, specified the learning objectives and assessed students' entering behavior. We also determined the strategy to be used, organized the group, considered the allocation of time and space and finally selected suitable resources in designing the IMMPA EC Lab. Next, we designed the message in the content delivery and arrange the instructional delivery. Evaluation instruments were also developed as the last part of every sub unit in the IMMPA EC Lab to assess students' understanding in each sub unit. When everything was done, a formative evaluation was carried out to evaluate the module developed.

1.2.1 Formative Evaluation

The main purpose of the formative evaluation is to inform the instructor or planning team how well the instructional program has been serving the objectives as it progresses (Morrison, Ross & Kemp, 2007). Hence, the formative evaluation should be conducted at different stages during the development of the IMMPA EC Lab. Dick and Carey (1991) suggested three stages of formative evaluation when designing an instruction, namely one-to-one trials, small-group trials and field trials. Descriptions of the stages with the related instruction phase, purpose, respondents and instruments are displayed in Table 1.

Table 1. Stages of Formative Evaluation

Stage	Instruction Phase	Purpose	Learners	Main Measures
One-to-one trials	Development	Try-out impressions	Individuals	Observation, survey, interview
Small-group trials	Preliminary/draft version	Identify strengths/weakness	Small groups (8-20)	Observation, attitudes, performance
Field trials	Completed	Assess actual implementation	Regular classes	Performance, attitudes

As shown in Table 1, we carried out one-to-one trials during the development phase. Next, we carried out small-group trials followed by field trials. This paper will concentrate on details of the small-group trials to test whether the module developed is usable and effective in learning Electrochemistry.

Flagg (1990) suggested four types of formative evaluation, namely connoisseur-based studies, decision-oriented studies, objectives-based studies and public relations-inspired studies. In our case, we decided to combine the connoisseur-based study approach and objective-based study approach as our method of formative evaluation. We selected the connoisseur-based study approach because it employs subject matter experts and other appropriate consultants (media and design experts) to examine the instruction and give opinions regarding its accuracy and effectiveness. The IMMPA EC Lab was examined by some experts in Electrochemistry, language experts and instructional designers to maintain the quality of IMMPA EC Lab in terms of content and instructional design. In addition, we administered pre- and post achievement tests and motivation questionnaires to measure the amount of gain on measures of achievement and attitude as the objectives-based study approach.

1.3 Research Questions and Hypotheses

The study was carried out as a formative evaluation for the development of IMMPA EC Lab. This formative evaluation is a combination of connoisseur-based study and objectives-based study approaches. The research questions and hypotheses that drive this formative evaluation are as follows:-

1) What is the quality level of IMMPA EC Lab from students' point of view?
2) What is the quality level of IMMPA EC Lab from experts' point of view?
3) Is IMMPA EC Lab a reliable multimedia module in the learning of Electrochemistry?
4) Is IMMPA EC Lab a valid multimedia module in the learning of Electrochemistry?
5) H_{01}: There is no significant difference between the mean scores in achievement test before and after the intervention.
6) H_{02}: There is no significant difference between the mean scores in motivation before and after the

intervention.

2. Method

2.1 Respondents

Seven experts from different areas (content, chemistry education, instructional design/e-learning) were selected as respondents for the connoisseur-based study. They evaluated IMMPA EC Lab in terms of pedagogical content of Electrochemistry, language, instructional design and validity of the module.

Thirty-five Form Four students were selected as respondents for the objectives-based study to investigate the effect of IMMPA EC Lab on students' knowledge and motivation in learning Electrochemistry. Besides that, they were asked to evaluate the usability of IMMPA EC Lab in terms of quality and reliability of the module. The respondents consisted of 13 male and 22 female students (aged 16 years), and the majority of them are Malays. As for small-group trials, there were 8-20 respondents (Table 1). Hence, it is argued that 35 students in our study are more than enough for the objective-based study.

2.2 Materials

Materials utilized in the study are the IMMPA EC Lab, module evaluation questionnaire, module reliability questionnaire, module validity questionnaire, pretest, post-test and motivation questionnaire.

2.2.1 IMMPA EC Lab

IMMPA EC Lab was developed using the KemGerly Model. There are two PAs in the IMMPA EC Lab, namely Professor T and Lisa. Professor T is a sixty-year-old male PA who acts as an expert in Electrochemistry. He gives accurate information and explains new concepts to the students. Professor T speaks slowly in a formal way with little body gestures and facial expressions. On the other hand, Lisa is a fifteen-year-old female who speaks with an energetic voice. She is a learning companion in the IMMPA EC Lab. She learns together with the students, as well as motivates and encourages the students to complete the tasks and exercises in the module. Students are free to choose the PA they want to accompany them in learning Electrochemistry when using the IMMPA EC Lab.

The main menu for the IMMPA EC Lab consists of tutorials, experiments, exercises, quizzes, memos and games. There are five sub units in the IMMPA EC Lab: (1) Electrolytes and Non-Electrolytes, (2) Electrolysis of Molten Compounds, (3) Electrolysis of Aqueous Solutions, (4) Voltaic Cells and (5) Types of Voltaic Cells. The complete flow of each sub unit follows the five phases in the learning process created by Needham (1987). The five phases are orientation, elicitation of ideas, restructuring of ideas, application of ideas and review. The relationship between sessions in IMMPA EC Lab and Needham phases is summarized in Table 2 below.

Table 2. Needham Phases and Sessions in IMMPA EC Lab

Needham Phases	Sessions in every Sub unit	Main Menu
Orientation	Think about it!	
Elicitation of Ideas	Do you still remember?	
Restructuring of Ideas		
• Clarification and exchange	Give me your ideas...	Tutorial
• Exposure to conflict situation	Are you sure?	
• Construction of new ideas and evaluation	Let's do it!! / Show time!	Experiment
Application of Ideas	Practice makes perfect!	Exercise
Review	Before & after...	
	Test yourself	Quiz
	Challenge yourself	
		Memo
		Game

All the information delivery for the sub units is presented in the tutorial session. The experiment session consists of five experiments. After the information delivery process, the students will attempt some exercises to enhance their understanding on the concepts learnt. A quiz is given at the end of every sub unit. A memo is created to give some notes on Electrochemistry concepts. There are four activities in the game session to let the students relax their mind after the learning process.

2.2.2 Module Evaluation Questionnaire

A module evaluation questionnaire was used to evaluate the quality of the module based on some components in the module. The components and number of items in the module evaluation questionnaire for both student and expert versions are summarized in Table 3. The items for PAs' evaluation components were created according to the agents' characteristics in Agent Persona Instrument (API) by Baylor and Ryu (2003). We referred to previous researches (Baylor, Ryu & Shen, 2003; Brünken, Plass, & Leutner, 2004; Chandler & Sweller, 1992; Craig et al., 2002; Kirk, 2008; Mayer & Moreno, 1998; Mayer, Dow & Mayer, 2003; Mayer, Fennell, Farmer & Campbell, 2004; Mayer, Sobko & Mautone, 2003; Moreno & Mayer, 2000; Moreno & Mayer, 1999; Moreno et al., 2000; Mousavi, Low & Sweller, 1995; Paas & Van Merriënboer, 1994; Paas, Renkl & Sweller, 2003; Pollock, Chandler & Sweller, 2002; Sweller & Chandler, 1994; Van Gerven, Paas, Van Merriënboer, & Schmidt, 2002; Van Merrienboer, Kirschner & Kester, 2003) to create items about evaluation of Cognitive Load Theory and Cognitive Theory of Multimedia Learning.

Table 3. Components in Module Evaluation Questionnaire

	Components	Total Items	
		Students	Experts
I.	Screen design		
	A. Text	4	4
	B. Colour	4	4
	C. Graphic	6	6
	D. Animation	3	3
	E. Video	3	3
	F. Audio	7	7
II.	Navigation & Interactivity	13	13
III.	Language	7	7
IV.	Content	11	11
V.	Interest & Motivation	10	10
VI.	Pedagogical agent		
a)	Professor T		
	A. Facilitating Learning	10	10
	B. Credible	5	5
	C. Human-like	5	5
	D. Engaging	5	5
b)	Lisa		
	A. Facilitating Learning	10	10
	B. Credible	5	5
	C. Human-like	5	5
	D. Engaging	5	5
VII.	Application of Theory		
a)	Behaviourism Theory	-	9
b)	Cognitivism Theory	-	8
c)	Constructivism Theory	-	12
d)	Cognitive Load Theory		
	A. Intrinsic cognitive load	-	8
	B. Extraneous cognitive load		
	Split attention effect	-	8
	Worked-example effect	-	9
	Modality effect	-	9
	Redundancy effect	-	5
	C. Germane cognitive load	-	7
e)	Cognitive Theory of Multimedia Learning		
	A. Personalization principle	-	7
	B. Modality principle	-	9
	C. Spatial contiguity principle	-	7
	D. Temporal contiguity principle	-	7
	E. Redundancy principle	-	5
	F. Voice principle	-	8
	G. Interactivity principle	-	11
Total		118	247

The questionnaire was given to both students and experts to compare the quality of module from their point of view. Similar questionnaires were given to the students and experts with some addition of components in the experts' version.

2.2.3 Module Reliability Questionnaire

A module reliability questionnaire was developed by the researchers with reference to the examples suggested by Sidek and Jamaludin (2005). Items in the module reliability questionnaire were developed based on activities in the IMMPA EC Lab because they are better compared to items created based on objectives of the module (Sidek & Jamaludin, 2005). The distribution of items based on activities in IMMPA EC Lab is summarized in Table 4.

Table 4. Item Distribution in Module Reliability Questionnaire

Sessions in every Sub unit	Total items
Front page of sub units	3
Objectives	4
Think about it!	6
Do you still remember?	4
Give me your ideas...	4
Are you sure?	4
Let's do it!! / Show time!	7
Practice makes perfect!	6
Before & after...	4
Test yourself!	4
Challenge yourself!	4
Total	50

2.2.4 Module Validity Questionnaire

We referred to Sidek's and Jamaludin's suggestions and developed the items in our module validity questionnaire based on characteristics of module validity suggested by Russell (1974). All the characteristics required and the items related are summarized in Table 5.

Table 5. Item Distribution in Module Validity Questionnaire

Characteristics of Module Validity	Total items
Accurate target population	5
The teaching situation or implementation method is done very well	5
Enough time to implement the whole module	5
Potential to increase students' academic achievement	5
Potential to change students' behavior to be excellent in life	5
Total	25

2.2.5 Achievement Tests

Achievement tests were administered in the form of pretest and post-test before and after the intervention. There are two structured questions in the achievement tests. The questions test knowledge on electrolytic cell and voltaic cell concepts at the macroscopic, microscopic and symbolic levels. Questions in the pretest and post-test are similar in terms of difficulty level and concept tested. The concepts tested and numbers of items in the achievement tests are summarized in Table 6.

Table 6. Distribution of Items in Achievement Tests

Concept	Item Distribution		Representation Level
	Electrolytic Cell	Voltaic Cell	
Flow of current in the conductors and in the electrolytes	c (i), c (ii)	c (i), c (ii)	Microscopic
Identify the anode and cathode		k, l (i), l (ii), m (i), m (ii)	Macroscopic Microscopic
Identify the process happening at the anode and cathode	a (i), a (ii), b	a (i), a (ii), b	Macroscopic
Oxidation and reduction process	e (i), e (ii), f	e (i), e (ii), f	Microscopic Symbolic
Concept of Electrolyte	j	j	Microscopic

2.2.6 Motivation Questionnaire

The motivation questionnaire is a Likert scale questionnaire. The distribution of items in the motivation questionnaire is shown in Table 7.

Table 7. Item Distribution in Motivation Questionnaire

Sub dimension	Item Distribution
Intrinsic goal orientation	1, 13, 19, 21
Extrinsic goal orientation	6, 9, 27
Task value	8, 14, 20, 23, 24
Control of learning belief	2, 7, 15, 22
Self-Efficacy for learning and performance	4, 5, 10, 12, 17, 18, 26, 28
Test anxiety	3, 11, 16, 25

As highlighted in Table 7, there are six constructs involved, namely intrinsic goal orientation, extrinsic goal orientation, task value, control of learning belief construct, self-efficacy for learning and performance and test anxiety. There is a total of 28 items in the questionnaire with the Likert scale ranging from 1 – Strongly Disagree to 5 – Strongly Agree. Items in the questionnaire have been taken from the study of Sadiah and colleagues (2009) which were translated from the instrument used by Pintrich and DeGroot (1990). In this study, the researchers used the motivation section only and changed the scale from seven points to five points.

2.3 Procedure

For the connoisseur-based study, the experts were given IMMPA EC Lab, a module evaluation questionnaire and a module validity questionnaire. They need to explore the IMMPA EC Lab and then answer the module evaluation questionnaire and module validity questionnaire.

For the objectives-based study, respondents were given the pretest and motivation questionnaire to gauge their existing knowledge in Electrochemistry and their motivation level before they study Electrochemistry with IMMPA EC Lab. They were given 60 minutes to answer the pretest and 15 minutes to answer the motivation questionnaire. Then the respondents were gathered at the computer laboratory and briefed on how to use the IMMPA EC Lab. Respondents then started to explore the IMMPA EC Lab. Finally, they were given the post-test and motivation questionnaire.

3. Results

3.1 Quality of IMMPA EC Lab

The quality of the module was determined by the module evaluation questionnaire. Similar questionnaires were given to both students and experts to determine their view on the quality of the IMMPA EC Lab. The students

rated IMMPA EC Lab as high quality with a mean of 3.94 (SD = 0.32) while experts rated it as very high quality with a mean of 4.45 (SD = 0.40). Means for all components in IMMPA EC Lab are shown in Table 8.

Table 8. Mean scores for All Components in Module Evaluation Questionnaire

Components		Students			Experts		
		Mean	SD	Quality	Mean	SD	Quality
I.	Screen design	3.95	0.37	High	4.37	0.35	Very high
	A. Text	4.04	0.45	High	4.71	0.30	Very high
	B. Colour	4.05	0.48	High	4.25	0.50	Very high
	C. Graphic	4.22	0.47	Very high	4.43	0.42	Very high
	D. Animation	4.15	0.53	High	4.62	0.41	Very high
	E. Video	4.04	0.58	High	4.10	0.42	High
	F. Audio	3.46	0.57	High	4.18	0.56	High
II.	Navigation & Interactivity	4.10	0.40	High	4.59	0.33	Very high
III.	Language	3.99	0.49	High	4.65	0.32	Very high
IV.	Content	4.21	0.40	Very high	4.55	0.45	Very high
V.	Interest & Motivation	3.77	0.49	High	4.20	0.59	High
VI.	Pedagogical agent						
a)	Professor T	3.72	0.59	High	4.21	0.73	Very high
	A. Facilitating Learning	3.62	0.70	High	4.31	0.86	Very high
	B. Credible	4.06	0.61	High	4.40	0.49	Very high
	C. Human-like	3.58	0.68	High	4.06	0.85	High
	D. Engaging	3.71	0.75	High	3.94	0.75	High
b)	Lisa	3.84	0.38	High	4.02	0.72	High
	A. Facilitating Learning	3.90	0.48	High	4.01	0.66	High
	B. Credible	3.75	0.50	High	4.26	0.70	Very high
	C. Human-like	3.67	0.51	High	3.86	0.94	High
	D. Engaging	3.97	0.53	High	3.97	0.82	High
VII.	Application of Theory						
a)	Behaviourism Theory	-	-	-	4.65	0.40	Very high
b)	Cognitivism Theory	-	-	-	4.48	0.50	Very high
c)	Constructivism Theory	-	-	-	4.60	0.45	Very high
d)	Cognitive Load Theory	-	-	-	4.60	0.35	Very high
	A. Intrinsic cognitive load	-	-	-	4.65	0.42	Very high
	B. Extraneous cognitive load	-	-	-	4.61	0.35	Very high
	Split attention effect	-	-	-	4.54	0.47	Very high
	Worked-example effect	-	-	-	4.70	0.47	Very high
	Modality effect	-	-	-	4.83	0.21	Very high
	Redundancy effect	-	-	-	3.97	0.81	High
	C. Germane cognitive load	-	-	-	4.45	0.39	Very high
e)	Cognitive Theory of Multimedia Learning	-	-	-	4.57	0.31	Very high
	A. Personalization principle	-	-	-	4.59	0.29	Very high
	B. Modality principle	-	-	-	4.79	0.20	Very high
	C. Spatial contiguity principle	-	-	-	4.65	0.35	Very high
	D. Temporal contiguity principle	-	-	-	4.65	0.44	Very high
	E. Redundancy principle	-	-	-	3.89	0.85	High
	F. Voice principle	-	-	-	4.39	0.59	Very high
	G. Interactivity principle	-	-	-	4.73	0.23	Very high
Total		3.94	0.32	High	4.45	0.40	Vey high

3.2 Module Reliability

A module reliability questionnaire was administered to the students to determine the reliability of IMMPA EC Lab. The students rated the module as highly reliable with a mean of 3.87 (SD = 0.41). Means for all sessions in the IMMPA EC Lab are shown in Table 9.

Table 9. Mean scores for All Sessions in IMMPA EC Lab

Sessions in every Sub unit	Mean	SD	Reliability
Front page of sub units	4.12	0.54	High
Objectives	3.66	0.54	High
Think about it!	3.76	0.41	High
Do you still remember?	3.81	0.47	High
Give me your ideas...	3.96	0.60	High
Are you sure?	3.97	0.56	High
Let's do it!!/Show time!	3.80	0.55	High
Practice makes perfect!	3.91	0.49	High
Before & after...	4.04	0.56	High
Test yourself!	3.76	0.52	High
Challenge yourself!	3.81	0.50	High

3.3 Module Validity

A module validity questionnaire was administered to experts to evaluate the module in terms of validity. All the items in the questionnaire were based on the characteristics of module validity. The experts rated IMMPA EC Lab as a very highly valid module (M = 4.51, SD = 0.20). The mean value for each characteristic of module validity is summarized in Table 10.

Table 10. Mean Scores for each Characteristic of Module Validity

Characteristics of Module Validity	Mean	SD	Validity
Accurate target population	4.66	0.32	Very high
The teaching situation or implementation method is done very well	4.60	0.31	Very high
Enough time to implement the whole module	4.14	0.40	High
Potentially to increase students' academic achievement	4.66	0.25	Very high
Potentially to change students' behavior to be excellent in life	4.51	0.45	Very high
Total	4.51	0.20	Very high

3.4 Achievement Tests

To carry out the objectives-based studies, achievement tests were given in the form of pretest and post-test before and after the intervention. The results of the pretest and post-test were used to examine the effect of IMMPA EC Lab on students' understanding in Electrochemistry. Table 11 shows the t-test results for the pretest and post-test.

Table 11. T-test table for Students' Achievement Tests

Test	N	Mean	Std. Deviation	t value	Sig (2-tailed)
Post-test	35	26.98	13.61	8.97	0.000*
Pretest	35	9.42	5.71		

A paired-sample t-test was conducted to evaluate the impact of the IMMPA EC Lab on the students' scores in the achievement test. There is a statistically significant increase in the achievement tests, from the pretest (M = 9.42, SD = 5.71) to the post-test [M = 26.98, SD = 13.61, $t(34) = 8.97$, $p < 0.05$]. The magnitude of the difference in the means is very large (eta squared = 0.5419) (Cohen, 1988). Hence, the first hypothesis is rejected which means that there is significant difference between the mean scores of the achievement test before and after the intervention.

3.5 Motivation Questionnaire

The motivation questionnaire was used to assess the students' goals and value beliefs for Chemistry (especially Electrochemistry), their beliefs in their ability to succeed in the subject and their anxiety toward the test and examination on Electrochemistry. Table 12 shows the t-test results for the motivation questionnaire in the study.

Table 12. T-test Table for Students' Motivation Level

Motivation	N	Mean	Std. Deviation	t value	Sig (2-tailed)
Post	35	3.68	0.34	2.42	0.021*
Pre	35	3.53	0.32		

Data shows that there is a statistically significant increase in the level of motivation from pre-questionnaire (M = 3.53, SD = 0.32) to the post-questionnaire [M = 3.68, SD = 0.34, $t(34) = 2.42$, $p < 0.05$]. The eta square is 0.079, which is considered to be a moderate effect size [41]. Hence, a second hypothesis is rejected; this implies that there is significant difference between the mean scores in motivation before and after intervention.

4. Discussion

The most important thing in a multimedia module is how the multimedia elements are used to express the content in a meaningful way and hence, to deliver it effectively to users. The multimedia elements used in IMMPA EC Lab were text, graphic, animation, simulation, video, audio and navigation. All these elements were evaluated in the module evaluation questionnaire. The students rated the highest mean for the graphic element among all the multimedia elements, while the experts' highest mean is for the text element. The use of representational graphic (Levin, 1981) in IMMPA EC Lab made the information easier and more meaningful to the students. Text structures (Armbruster, 1986) and typographical signals made important texts more obvious. Consequently, students can identify the important part of the content and help them to prepare notes in the learning process.

We found that students and experts were having different judgments regarding the PAs in IMMPA EC Lab. Lisa was more favored among the students but the experts preferred Professor T. Students rated Lisa as a better facilitator in learning, more human-like and more engaging as compared to Professor T. On the other hand, experts felt that Professor T is better at facilitating learning, more credible and more human-like compared to Lisa. Although both students and experts have different views about the PAs, both of them agreed that Professor T is more credible and Lisa is more engaging. Professor T as the expert in Electrochemistry always gives accurate information to the students in the learning process, so both students and experts rated him as more credible. On the other hand, Lisa as a learning companion, speaks in an energetic voice and always motivates and encourages the students, hence they rated her as more engaging.

Application of theories gaining very high mean scores indicates that all the content delivery sequence, arrangement of text and graphic, design of the screen, use of multimedia elements, strategy, and techniques used in IMMPA EC Lab were following the principal and concepts in Behaviourism Theory, Cognitivism Theory, Constructivism Theory, Cognitive Load Theory and Cognitive Theory of Multimedia Learning. However, the mean for redundancy effect and redundancy principal is quite low compared to means for other effects in Cognitive Load Theory and principals in Cognitive Theory of Multimedia Learning. Experts felt that texts displayed on the screen when the narration is given are redundant (Craig, Driscoll, & Gholson, 2004; Craig et al., 2002; Sweller & Chandler, 1994) to the learners because the information is the same. Students' working memory was loaded because they had to read the text and listen to the narration at the same time. The language used in IMMPA EC Lab is English, following the Teaching and Learning of Science and Mathematics using English Project (Pengajaran dan Pembelajaran Sains dan Matematik dalam Bahasa Inggeris, PPSMI) implemented by the government since 2003. Comprehension of the decoded message is affected by the ability of the receiver to comprehend the message (Heinich, Molenda, Russel, & Smaldino, 2002). Since English is not our mother tongue,

it would create problems in delivering information from PAs to students if only audio communication is involved. Hence, on some of the screens, we have decided to deliver the information in both audio and visual forms.

High mean scores for every part in IMMPA EC Lab indicated that the module is reliable to be used as a learning module in Electrochemistry. The items in the module reliability questionnaire were developed according to the activities in IMMPA EC Lab. High mean scores for the module reliability showed that the students were able to follow all the steps and activities in IMMPA EC Lab successfully (Russell, 1974).

The overall mean for module validity is very high indicating that all the experts agreed that the IMMPA EC Lab is a valid learning module according to the characteristics of module validity suggested by Russell (1974). Majority of the experts agreed that the content of IMMPA EC Lab is following the Chemistry syllabus and the students can fulfill all the objectives through the activities designed. The use of animations and videos helped the students in understanding the concepts of Electrochemistry especially at microscopic level.

Students showed improvement in the achievement test, indicating that they gained knowledge about Electrochemistry after learning with IMMPA EC Lab. This showed that IMMPA EC Lab is effective in increasing students' knowledge. However, we found that students are still weak in certain Electrochemistry concepts especially at microscopic and symbolic levels. For instance, the students still could not differentiate between the flow of electrons in the conductors and the flow of ions in the electrolytes (Kamisah & Lee, 2012; Lee & Mohammad Yusof, 2009; Lee, 2008; Özkaya, Üce & Şahin, 2003; Sanger & Greenbowe, 1997a). Besides that, we found that students always assumed that anions would be attracted to the cathode while cations would be attracted to the anode (Kamisah & Lee, 2012; Lee & Mohammad Yusof, 2009; Lee, 2008). This is because anions are negative ions and the students in this study assumed that negative ions would be attracted to negative electrode and vice versa. However, students' results showed improvement from pretest to post-test, indicating that the animations in the *Micro-World* had helped the students in understanding Electrochemistry concepts microscopically. The use of multimedia creates the environment where students could visualize the abstract chemical processes via animations and videos at macroscopic, microscopic and symbolic levels (Bowen, 1998; Burke et al. 1998; Rodrigues et al. 2001; Russell et al. 1997).

Overall, the students' motivation level increased for each construct in the motivation questionnaire except for the test anxiety construct which maintained the same. The mean value for self-efficacy for learning and performance construct showed the biggest increase from 3.30 (SD = 0.42) to 3.54 (SD = 0.50) after the students had studied with the IMMPA EC Lab. Self-efficacy refers to personal beliefs about having the means to learn or perform effectively (Zimmerman, 2000). High self-efficacy beliefs enabled the students to be more motivated to learn Electrochemistry and hence, their test anxiety level was low (M = 2.06, SD = 0.67). High self-efficacy values are related to relatively high intrinsic motivation values. In this study, the students' intrinsic goal orientation value is 3.84 (SD = 0.48), showing that the students enjoyed learning with the IMMPA EC Lab. The variety of feedback given by the PAs and the videos shown during the discussions attracted the students' attention to study the topic. The students showed the highest extrinsic goal orientation (M = 4.54, SD = 0.40) among all the constructs, indicating that they were trying to show to others that they could perform well in Chemistry.

We considered the suggestions and recommendations by students and experts, and made some corrections and improvements accordingly. For instance, some of the important keywords in the answer scheme were highlighted so that students will take note of them. The button for printing function was added to some of the screens so that users can print out related pages. One of the experts mentioned about adding the concentration cell in IMMPA EC Lab, but we did not consider it because the concentration cell is not in the syllabus for Form Four Chemistry. Some students complained that the background music was annoying and affecting their concentration during the learning process. The background music is actually interactive; users can turn it off if they do not wish to listen. We do not plan to get rid of the background music as some students may have strong musical intelligence and need music in the learning process.

5. Conclusion

The formative evaluation has been carried out in the form of objectives-based study and connoisseur-based study approaches involving some students and experts. Students' acquisition of knowledge and motivation levels were tested and measured via the achievement tests and motivation questionnaire. Results showed statistically significant increment of test scores and motivation mean scores after the intervention. The objectives-based study has proven that the IMMPA EC Lab developed is effective in raising students' knowledge and motivation level in the learning of Electrochemistry. This is parallel with studies abroad (Johnson et al., 2000; Kizilkaya & Askar, 2008; Moundridou & Virvou, 2002; Moreno, Mayer & Lester, 2000) where students were found to be more motivated and interested, and achieved higher performance when learning with tutorials supported by PAs.

On the other hand, the connoisseur-based study involving some experts in Electrochemistry and instructional design was carried out to evaluate the quality of the module developed. Experts rated IMMPA EC Lab as of very high quality and the content is valid. Besides that, results from students also showed that the module is reliable and they managed to carry out the activities in the module.

Suggestions and recommendations from respondents were considered and some corrections have been made to improve the quality of IMMPA EC Lab. We hope that IMMPA EC Lab can meet requirements for students from different backgrounds and become their learning aid in the learning of Electrochemistry. Field trials in the form of summative evaluation would be carried out to evaluate the improved IMMPA EC Lab. The purpose of summative evaluation is to assess the actual implementation of IMMPA EC Lab and study its effectiveness in improving students' knowledge and motivation in learning Electrochemistry. The number of respondents should be increased and another study would be carried out using quasi-experimental design to compare the outcomes between control and treatment groups. It is hoped that the improved IMMPA EC Lab is able to increase students' knowledge and enhance their motivation in the learning of Electrochemistry.

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